REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978
APPLICATION FOR A PAT[illegible] AND
ACKNOWLEDGEMENT OF RECEIPT
(Section 30(1) Regulation 22)

REPUBLIC OF SOUTH AFRICA
REVENUE
19.8.94 R 314.00
REPUBLIEK VAN SUID AFRIKA
INKOMSTE 370

FORM P.1
(to be lodged in duplicate)

THE GRANT OF A PATENT IS HEREBY REQUESTED BY THE UNDERMENTIONED APPLICANT ON THE BASIS OF THE PRESENT APPLICATION FILED IN DUPLICATE

A & A REF: 72957

PATENT APPLICATION NO.		
21	01	946337
71	*FULL NAME(S) OF APPLICANT(S)*	

Dirk Jacobus KLEYNHANS

ADDRESS(ES) OF APPLICANT(S)

17 Cumnor Court, Main Road, Kenilworth 7700, Cape Town, Republic of South Africa

54	*TITLE OF INVENTION*

TESTING OF A VEHICLE SUSPENSION

ONLY THE ITEMS MARKED WITH AN "X" IN THE BLOCKS BELOW ARE APPLICABLE.

[X] THE APPLICATION CLAIMS PRIORITY AS SET OUT ON THE ACCOMPANYING FORM P.2
The earliest priority claimed is Country: ZA No: 93/3565 Date: 21 May 1993

[ ] THE APPLICATION IS FOR A PATENT OF ADDITION TO PATENT APPLICATION NO. |21|01|

[ ] THIS APPLICATION IS FRESH APPLICATION IN TERMS OF SECTION 37 AND BASED ON APPLICATION NO. |21|01|

THIS APPLICATION IS ACCOMPANIED BY:

[X] ~~A single copy of a provisional~~ or two copies of a complete specification of 16 pages.
[X] Drawings of 4 sheet(s).
[X] Publication particulars and abstract (Form P.8 in duplicate) (for complete only).
[X] A copy of Figure 1 of the drawings (if any) for the abstract (for complete only).
[ ] An assignment of invention.
[ ] Certified priority document(s) (State quantity):
[ ] Translation of the priority document(s).
[ ] An assignment of priority rights.
[X] A copy of Form P.2 and the specification of RSA Patent Application No. |21|01| 93/3565
[X] A Form P.2 in duplicate.
[X] A declaration and power of attorney on Form P.3.
[ ] Request for ante-dating on Form P.4.
[ ] Request for classification on Form P.9.
[ ] Request for delay of acceptance on Form P.4.

74	*ADDRESS FOR SERVICE:* Adams & Adams, Pretoria

DATED THIS 18th DAY OF August 1994

ADAMS & ADAMS
APPLICANTS PATENT ATTORNEYS

The duplicate will be returned to the applicant's address for service as proof of lodging but is not valid unless endorsed with official stamp

RECEIVED
OFFICIAL DATE STAMP
1994-08-19
REGISTRAR OF PATENTS

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PRETORIA

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978
DECLARATION AND POWER OF ATTORNEY
(Section 30 - Regulation 8, 22(i)(c) and 33)

FORM P.3

REPUBLIC OF SOUTH AFRICA
REVENUE
19.8.94
R 001.00
INKOMSTE
REPUBLIEK VAN SUID AFRIKA

PATENT APPLICATION NO.			A & A REF:	LODGING DATE	
21	01	946337		22	

FULL NAME(S) OF APPLICANT(S)	
71	Dirk Jacobus KLEYNHANS

FULL NAME(S) OF INVENTOR(S)	
72	Dirk Jacobus KLEYNHANS

EARLIEST PRIORITY CLAIMED	COUNTRY		NUMBER		DATE	
	33	ZA	31	93/3565	32	21 MAY 1993

NOTE: The country must be indicated by its International Abbreviation – see schedule 4 of the Regulations

TITLE OF INVENTION	
54	TESTING OF A VEHICLE SUSPENSION

I/We Dirk Jacobus KLEYNHANS

hereby declare that :–

1. I/We am/are the applicant(s) mentioned above;

** 2. ~~I/We have been authorized by the applicant(s) to make this declaration and have knowledge of the facts herein stated in the capacity of ________________ of the applicant(s);~~

*** 3. the inventor(s) of the abovementioned invention is/are the person(s) named above ~~and the applicant(s) has/have acquired the right to apply by virtue of *an assignment from the inventor(s);*~~

4. to the best of my/our knowledge and belief, if a patent is granted on the application, there will be no lawful ground for the revocation of the patent;

**** 5. this ~~is a convention application and the earliest application from which priority is claimed as set out above is the~~ first application ~~in a convention country in respect of the invention claimed in any of the claims~~; and

6. the partners and qualified staff of the firm of **ADAMS & ADAMS**, patent attorneys, are authorised, jointly and severally, with powers of substitution and revocation, to represent the applicant(s) in this application and to be the address for service of the applicant(s) while the application is pending and after a patent has been granted on the application.

SIGNED AT Cape Town THIS 18th DAY OF August 1994

SIGNATURE(S)
(no legalization necessary)

* *In the case of application in the name of a company, partnership or firm, give full names of signatory/signatories, delete paragraph 1, and enter capacity of each signatory in paragraph 2.*
** *If the applicant is a natural person, delete paragraph 2.*
*** *If the right to apply is not by virtue of an assignment from the inventor(s), delete* "an assignment from the inventor(s)" *and give details of acquisition of right.*
**** *For non-convention applications, delete paragraph 5.*

A&A P203

A & A REF: [illegible]

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PRETORIA

FORM P.7

REPUBLIC OF SOUTH AFRICA
Patents Act, 1978

COMPLETE SPECIFICATION

(Section 30(1) – Regulation 28)

OFFICIAL APPLICATION NO.

21 | 01 | 946337

LODGING DATE

22 | 19 August 1994

INTERNATIONAL CLASSIFICATION

51 | G01M, F16F

FULL NAME(S) OF APPLICANT(S)

71 | Dirk Jacobus KLEYNHANS

FULL NAME(S) OF INVENTOR(S)

72 | Dirk Jacobus KLEYNHANS

TITLE OF INVENTION

54 | TESTING OF A VEHICLE SUSPENSION

THIS INVENTION relates to a method of testing the operation of a vehicle suspension and more particularly the shock absorbers of such a suspension, and to apparatus for use in carrying out the method.

According to the invention there is provided a method of testing the operation of a vehicle suspension, which method includes determining the displacement of a sprung part of the vehicle with respect to an unsprung part of the vehicle (or ground) by means of sonic ranging, thereby to obtain a set of data corresponding to said displacement as a function of time, and transmitting the data, or data derived therefrom, to remote data processing means by means of a wireless data communication link.

Sonic ranging is to be understood as encompassing also ultrasonic ranging, and the term "sonic" in this specification should be interpreted accordingly.

The wireless data communication link may be a sonic data communication link, using the sonic transducer that was used to effect the sonic ranging.

The data transmitted to the remote data processing means may be processed by the remote data processing means.

The remote data processing means may include data storage means, in which event said data, or data derived therefrom, may be stored in the data storage means for subsequent retrieval.

Further according to the invention there is provided apparatus for testing the operation of a vehicle suspension, which apparatus comprises a tester unit including a sonic transducer for emitting a sonic signal to determine the displacement of a sprung part of the vehicle with respect to an unsprung part of the vehicle (or ground) by means of sonic ranging, a remote data receiving unit, and means for establishing a wireless data communication link between the tester unit and the receiving unit.

The wireless data communication link may be a sonic data communication link, said means including said sonic transducer.

The invention extend to a system for testing the operation of a vehicle suspension, the system comprising apparatus as aforesaid, and data processing means coupled to, or forming part of, the remote data receiving unit.

The data processing means may include data storage means for storing, for subsequent retrieval, the data received from the tester unit via the data receiving unit, or data derived therefrom.

The data processing means comprises a personal computer.

The invention will now be described in more detail, by way of example, with reference to the accompanying diagrammatic drawings.

In the drawings:

Figure 1 illustrates apparatus in accordance with the invention;

Figure 2 is a block diagram illustrating the ultrasonic ranging system of the apparatus;

Figure 3 is a block diagram of a controller forming part of the ranging system;

Figure 4 shows various graphs illustrating the ranging system waveforms and timing;

Figure 5 shows a graph illustrating the response of a vehicle suspension to a step excitation;

Figure 6 is a block diagram illustrating an ultrasonic communications link between a tester unit and an interface unit forming part of the apparatus; and

Figure 7 shows various graphs illustrating the timing and waveforms during transmission along the communications link.

Referring first to Figure 1, reference numeral 10 generally indicates apparatus for testing the operation of a vehicle suspension. The apparatus comprises a hand-portable

tester unit 12, a data receiving or personal computer interface (PCI) unit 14, and a host computer in the form of a personal computer (PC) 16.

The tester unit 12 is housed in a box which is provided with fixing means such as, for example, a suction cup or permanent magnet (not shown) for fixing the unit to the side of a vehicle body. It comprises an ultrasonic transducer (emit and receive) 18 which, when the unit is used in the ranging mode, should point in a direction which is perpendicular to the ground surface on which the vehicle is supported. To this end the fixing means is preferably provided with pivots (not shown) whose arrangement is such as to enable the orientation of the box to be adjusted after the tester unit has been fixed to the vehicle body. The unit 12 should be fixed as close as possible to the shock absorber being tested, ie adjacent the corresponding vehicle wheel, and there should be no obstructions between the unit and the ground surface.

The unit 12 comprises a power button 20, a transmit button 22, a test button 24, a green light emitting diode (LED) 26, an amber LED 28, and a red LED 30.

The PCI unit 14 comprises an ultrasonic transducer 32, a green LED 34, and an amber LED 36. It is located close to the PC 16 and connected to the PC by means of a cable 38.

Pressing the power button 20 will switch the unit 12 on if it is off, or off if it is on. The unit 12 will furthermore switch itself off if it is on and none of the buttons 20 to 24 has been pressed for a predetermined period. Immediately after the unit 12 has been switched on it automatically performs a battery test and the outcome is displayed on one of its LED's. Thus, a brief flashing of the red LED 30 will indicate that the battery needs to be replaced, a brief flashing of the amber LED 28 that the battery is running low, and a brief flashing of the green LED 26 that the battery is good. After having performed the battery test the unit 12 switches itself into a ready mode, which is indicated by the green LED 26 turning on.

To perform a test, the unit 12 is fixed to the vehicle body and adjusted as described above, and the test button 24 pressed. The amber LED 28 will then turn on to indicate that the unit 12 is ready to perform a test. The operator now presses down firmly on the vehicle, preferably above the wheel adjacent which the unit is mounted, and then releases the vehicle. Through ultrasonic ranging (as will be described in more detail hereinafter) the unit 12 will automatically detect when motion starts, and turn on the red LED 30 to indicate that a test is in progress. Furthermore, through ultrasonic ranging, the unit will commence to determine the distance from the unit to the ground surface a predetermined number of times at a predetermined sampling rate. In a practical example the distance measurement is

carried out 128 times at a rate which may be varied between 2 and 200 per second, thus providing 128 distance measurements.

When the sequence of 128 distance measurements has been completed the resulting data is processed in the unit 12, to perform a preliminary diagnosis of the shock absorber of the wheel adjacent which the unit 12 is mounted. A suitably programmed microprocessor in the unit 12 operates to calculate the damping ratio or percentage overshoot and to compare the calculated value with a table stored in an internal memory of the unit 12. Depending on the result of the comparison, the green LED 26, the amber LED 28, or the red LED 30 will start to flash, indicating respectively a 'pass', 'marginal', or 'fail' condition.

It will be appreciated that the unit 12 may be provided with a 7-segment display instead of the LED's 26, 28, and 30, in which event the 'pass', 'marginal', and 'fail' conditions, and other information if desired, can be indicated on the display in alphanumeric form.

For further diagnosis of the vehicle suspension the sampled data is transmitted to the PC 16, for further processing and graphical display. This transmission takes place by detaching the unit 12 from the vehicle, pointing the ultrasonic transducer 18 to the ultrasonic transducer 32, and pressing the transmit button 22. The transducer 18 and the transducer 32 form an ultrasonic communications link via

which the data is transmitted from the tester unit 12 to the PCI unit 14. While transmission is in progress the amber LED's 28 and 36 will be on. When the transmission has been completed, the amber LED's will turn off and the green LED's 26 and 34 will turn on. If the transmission is not successful (eg because of an obstruction between the units 12 and 14 or because of the unit 14 being out of range of the unit 12), the amber LED 36 will flash briefly, whereafter the unit 14 will return to the ready state (green LED 34 on). A suitably programmed microprocessor in the unit 14 will determine whether any errors occurred during transmission. If no errors occurred, the received data is passed on to the PC 16 for further processing and graphics display.

The distance measurement or ranging procedure will now be described with reference to Figures 2 to 4. The unit 12 comprises a microprocessor-based controller section 40, an oscillator section 42 coupled to a first ultrasonic transducer 44, and a detector section 46 coupled to a second ultrasonic transducer 48. The transducers 44 and 48 together constitute the transducer 18 of Figure 1.

The controller section 40 comprises a microprocessor 50 of the type having an integrated 16-bit programmable timer 52. It further comprises a flip-flop 53.

A range measuring sequence is started by the controller section 40 generating a pulse to turn on the

oscillator 42 for a period t_{ON}, and simultaneously to reset and start the internal timer 52. The ultrasonic transducer 44 converts the output of the oscillator 42 into an ultrasonic sound wave which is propagated through the air between the unit 12 and the ground surface (indicated by reference numeral 54 in Figure 2), reflected by the ground surface, and the reflected sound wave picked up by the ultrasonic transducer 48. The transducer 48 converts the sound wave back into an electrical signal which is detected by the detector 46. The detector 46 in turn pulses the controller unit 40 to indicate the arrival of the reflected sound wave. Upon detecting the arrival of the reflected sound wave the microprocessor stops its internal timer 52, reads the timer value (which is proportional to t_{DELAY}) and stores the value in memory. This process is repeated every t_{SAMP} seconds, until 128 measurements have been made.

While the timer 52 is enabled, it is incremented every t_{CLK} seconds by the microprocessor internal hardware. The final count (N) will therefore be given by:

$$N = \frac{t_{DELAY}}{t_{CLK}}$$

The time taken for a sound wave to travel a distance d is defined by the following relationship:

$$t_{DELAY} = \frac{d}{c_0}$$

where c_0 is the speed of sound in air (approximately 343 m/sec at room temperature and standard atmospheric pressure). The distance D between the unit 12 and the ground surface 54 satisfies the following equation:

$$N = \frac{2 * D}{c_0 * t_{CLK}} \qquad \text{..........(1)}$$

or

$$D = \frac{N * c_0 * t_{CLK}}{2} \qquad \text{..........(2)}$$

The equivalent distance is then calculated for each of the 128 measurements, using equation (2). The resulting set of data describes a displacement curve, such as the one shown in Figure 5, which can be analyzed to provide a diagnosis of the shock absorber performance. The curve shown in Figure 5 illustrates the displacement curve for a badly under-damped suspension.

Typical values for system parameters and timings are given in Table 1 below.

TABLE 1

Parameter	Minimum	Typical	Maximum	Units
t_{CLK}	0.1	3	200	μsec
t_{DELAY}	-	6	-	msec
t_{ON}	0.1	0.5	10	msec
t_{OSC}	5	25	50	μsec
t_{SAMP}	5	24	500	msec
N	32	128	8192	-

The oscillator 42 and the various transducers will typically operate at a frequency of 40 kHz.

Referring now to Figure 6, the ultrasonic transducer 44 (see also Figure 2) is also used to form a wireless data communication link between the tester unit 12 and the PCI 14, the ultrasonic transducer 32 (see also Figure 1) forming part of this link.

The tester unit 12, under control of its microprocessor 50, transmits the data as a synchronized serial bit-stream to the PCI unit 14, where it is fed to a microprocessor 55 of the PCI unit. Communication is simplex (ie in one direction only) and consists of synchronization information, data, and error detection information.

Circuitry in the PCI unit 14 establishes synchronization, receives and decodes the data, and then performs an error check to determine if any errors occurred during transmission. If any errors occurred, the amber LED

36 will flash briefly as described above, to indicate to the user that the data will have to be transmitted again.

The communication sequence is shown graphically in Figure 7. The sequence consists of a synchronization bit (SYNC BIT in the drawing) followed by a series of data bits (BIT 0 ... BIT n in the drawing). Each pulse in the sequence has a width of t_{PUL} and is spaced at intervals of t_{SP} seconds. If the data bit transmitted is binary "one", a pulse would be present, and if it is "zero" no pulse would be present. The microprocessor 55 of the PCI unit 14 samples the detector output stage 56 at regular intervals of t_{SP} seconds, which would be high if a binary "one" was sent or low if a binary "zero" was sent. The microprocessor 50 of the tester unit 12 starts the sequence by turning the oscillator 42 on for a period of t_{PUL} seconds to transmit the synchronization bit. The resulting sine-wave burst is propagated through the air and received by the transducer 32. The original pulse is reconstructed by a detector 56 and triggers the microprocessor 55 of the PCI unit 14 to synchronize and start the data sampling sequence.

When the rising edge of the reconstructed pulse is detected by the microprocessor 55, its internal timer is programmed to cause a delay of t_D seconds, where t_D is equal to one half of the original pulse width (t_{PUL}). After this delay the timer is programmed to repeatedly interrupt the microprocessor 55 every t_{SP} seconds. When interrupts occur,

the detector 56 output is sampled. This results in the detector 56 output being sampled exactly in the middle of each subsequent pulse, giving the least likelihood of an error. Any subsequent pulse would only be present at the sampling instant if a binary "one" is transmitted. Typical timing values are listed below in Table 2.

TABLE 2

Parameter	Minimum	Typical	Maximum	Unit
t_D	-	250	-	μsec
t_{PUL}	-	0.5	-	msec
t_{SP}	-	3	-	msec

CLAIMS:

1. A method of testing the operation of a vehicle suspension, which method includes determining the displacement of a sprung part of the vehicle with respect to an unsprung part of the vehicle (or ground) by means of sonic ranging, thereby to obtain a set of data corresponding to said displacement as a function of time, and transmitting the data, or data derived therefrom, to remote data processing means by means of a wireless data communication link.

2. A method as claimed in claim 1, wherein the wireless data communication link is a sonic data communication link, using the sonic transducer that was used to effect the sonic ranging.

3. A method as claimed in claim 1 or claim 2, wherein the data transmitted to the remote data processing means is processed by the remote data processing means.

4. A method as claimed in any one of the preceding claims, wherein the remote data processing means includes data storage means, said data, or data derived therefrom, being stored in the data storage means for subsequent retrieval.

5. Apparatus for testing the operation of a vehicle suspension, which apparatus comprises a tester unit including

a sonic transducer for emitting a sonic signal to determine the displacement of a sprung part of the vehicle with respect to an unsprung part of the vehicle (or ground) by means of sonic ranging, a remote data receiving unit, and means for establishing a wireless data communication link between the tester unit and the receiving unit.

6. Apparatus as claimed in claim 5, wherein the wireless data communication link is a sonic data communication link, said means including said sonic transducer.

7. A system for testing the operation of a vehicle suspension, the system comprising apparatus as claimed in claim 5 or claim 6, and data processing means coupled to, or forming part of, the remote data receiving unit.

8. A system as claimed in claim 7, wherein the data processing means includes data storage means for storing, for subsequent retrieval, the data received from the tester unit via the data receiving unit, or data derived therefrom.

9. A system as claimed in claim 8, wherein the data processing means comprises a personal computer.

10. A method of testing the operation of a vehicle suspension, substantially as herein described and illustrated.

11. Apparatus for testing the operation of a vehicle suspension, substantially as herein described and illustrated.

12. A system for testing the operation of a vehicle suspension, substantially as herein described and illustrated.

DATED THIS 18TH DAY OF AUGUST 1994

ADAMS & ADAMS
APPLICANT'S PATENT ATTORNEYS

DIRK JACOBUS KLEYNHANS

4 SHEETS
SHEET Nº 1

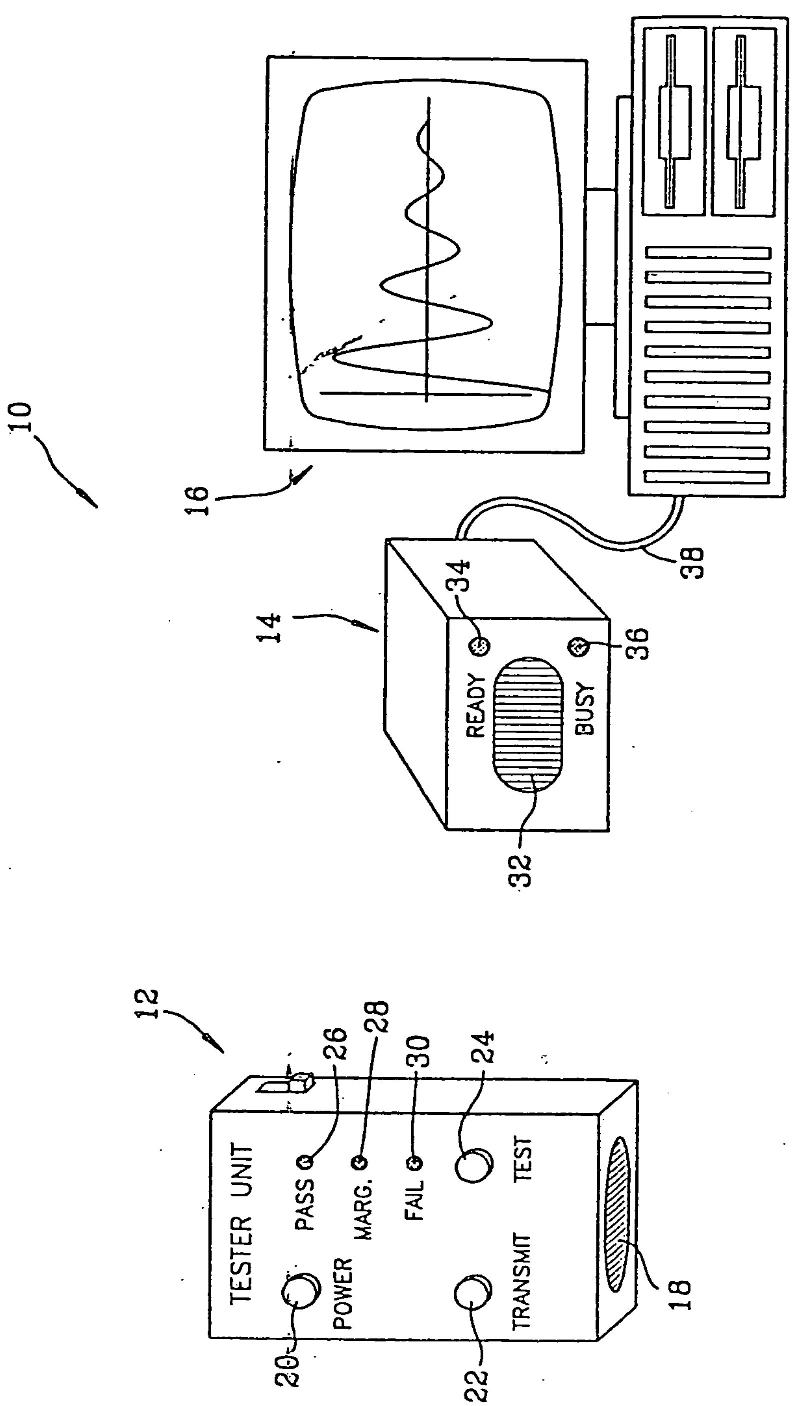

FIG 1

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4 SHEETS
SHEET Nº 2

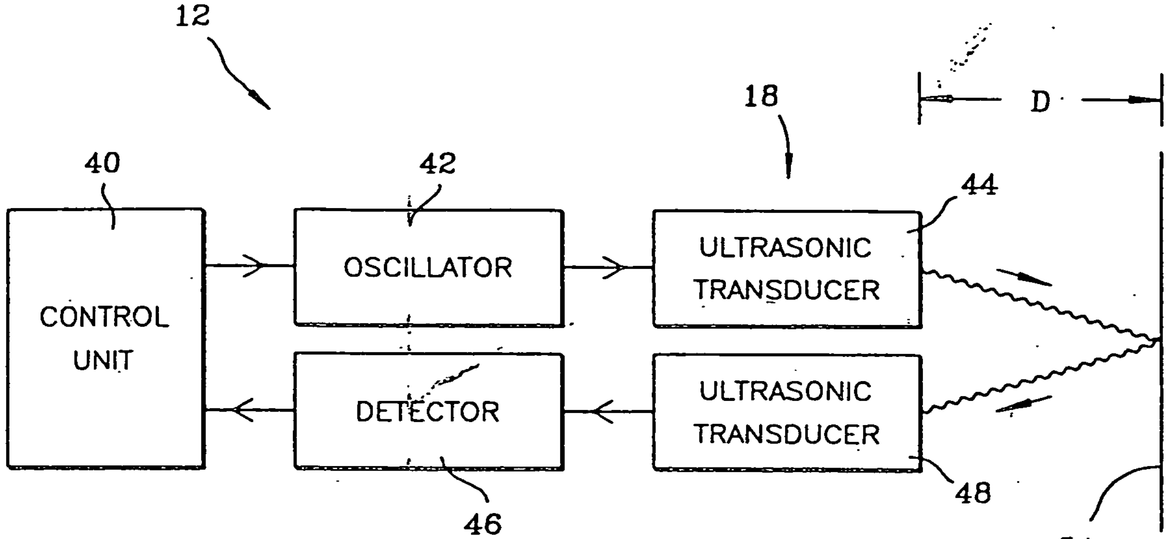

FIG 2

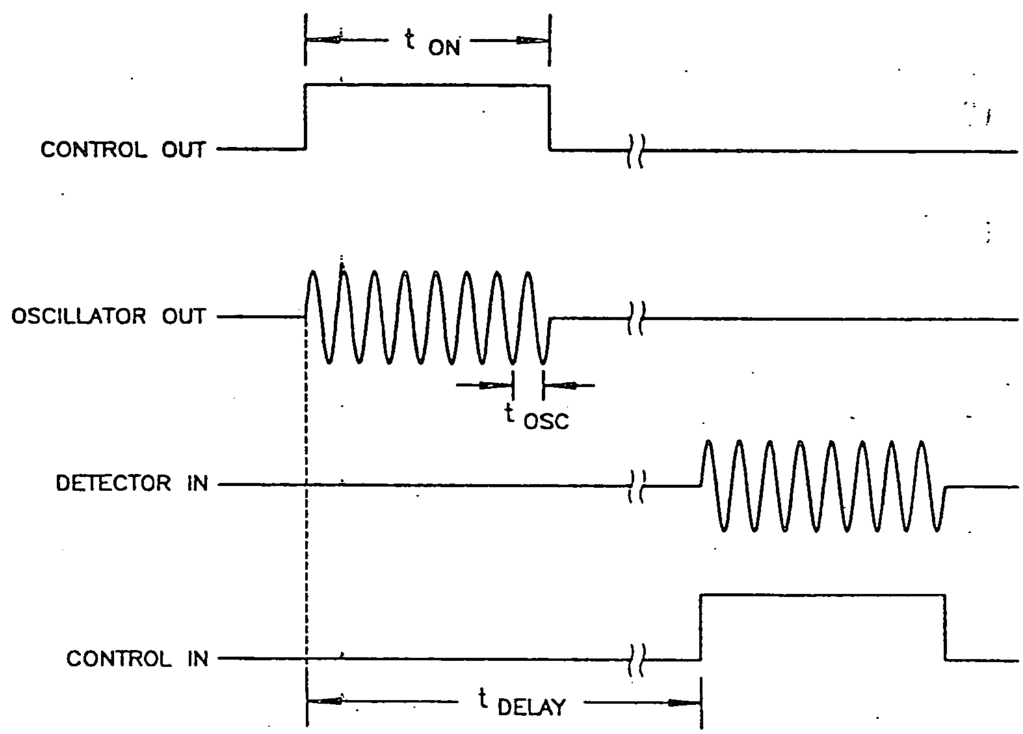

FIG 4

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4 SHEETS
SHEET Nº 3

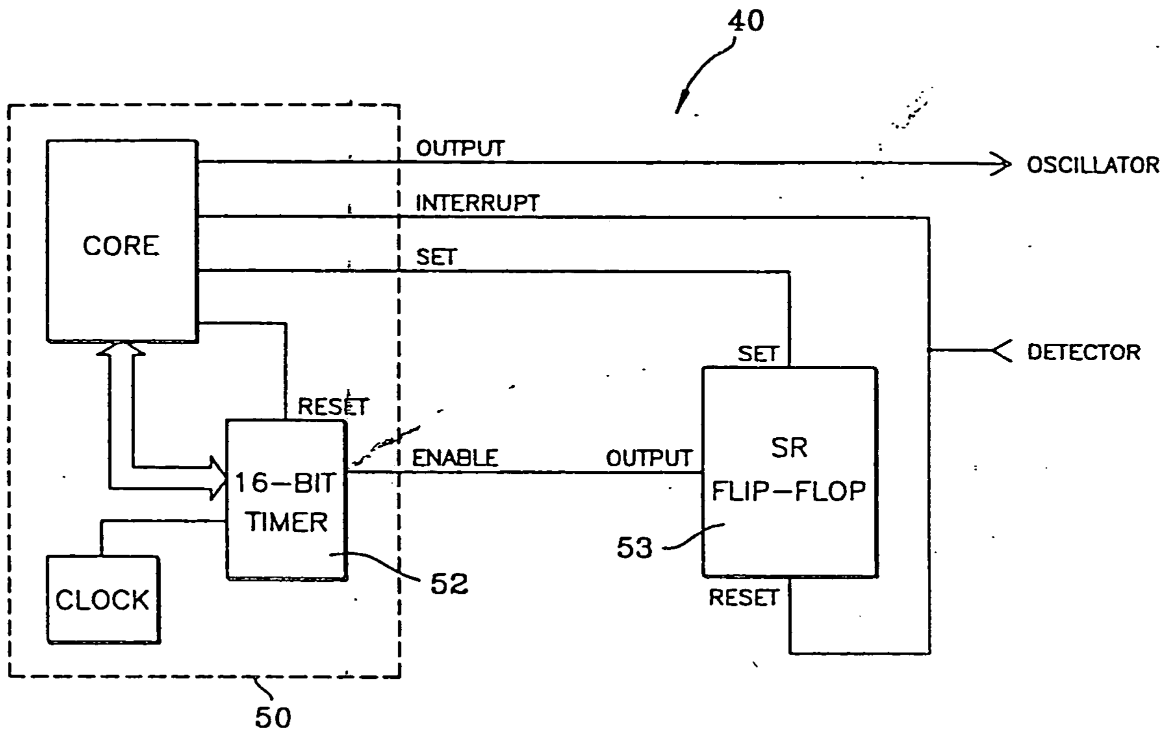

FIG 3

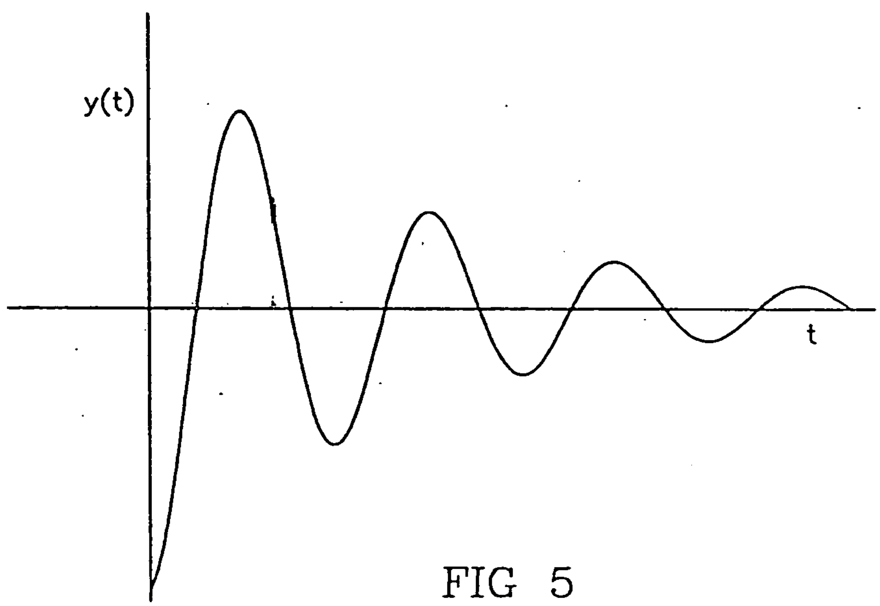

FIG 5

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4 SHEETS
SHEET Nº 4

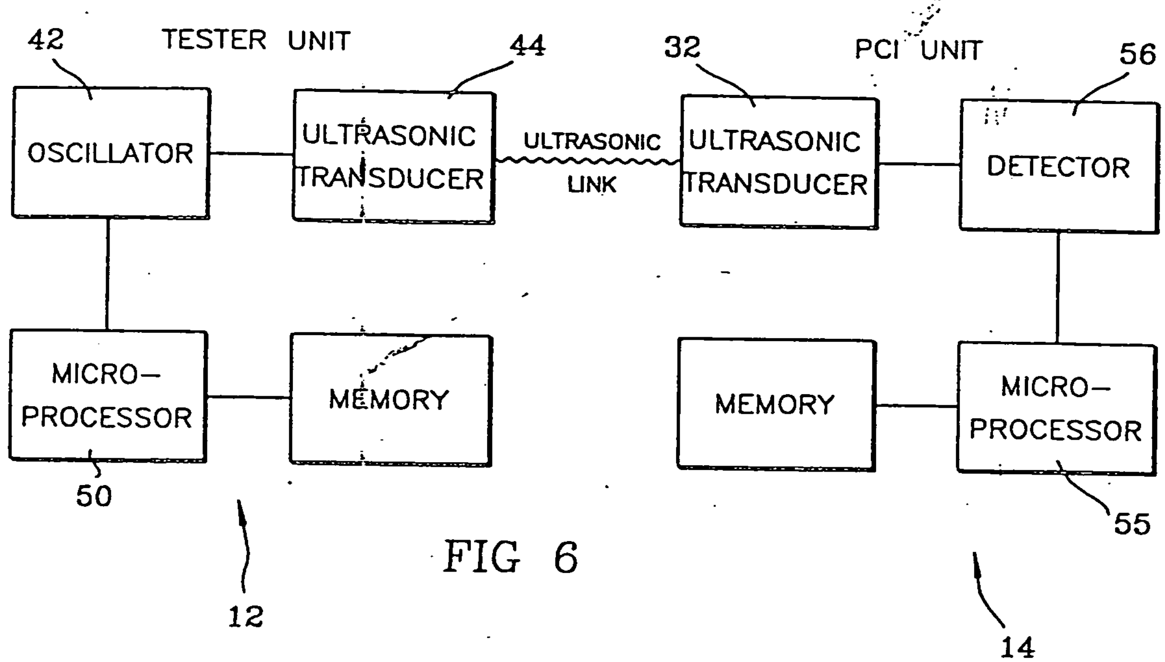

FIG 6

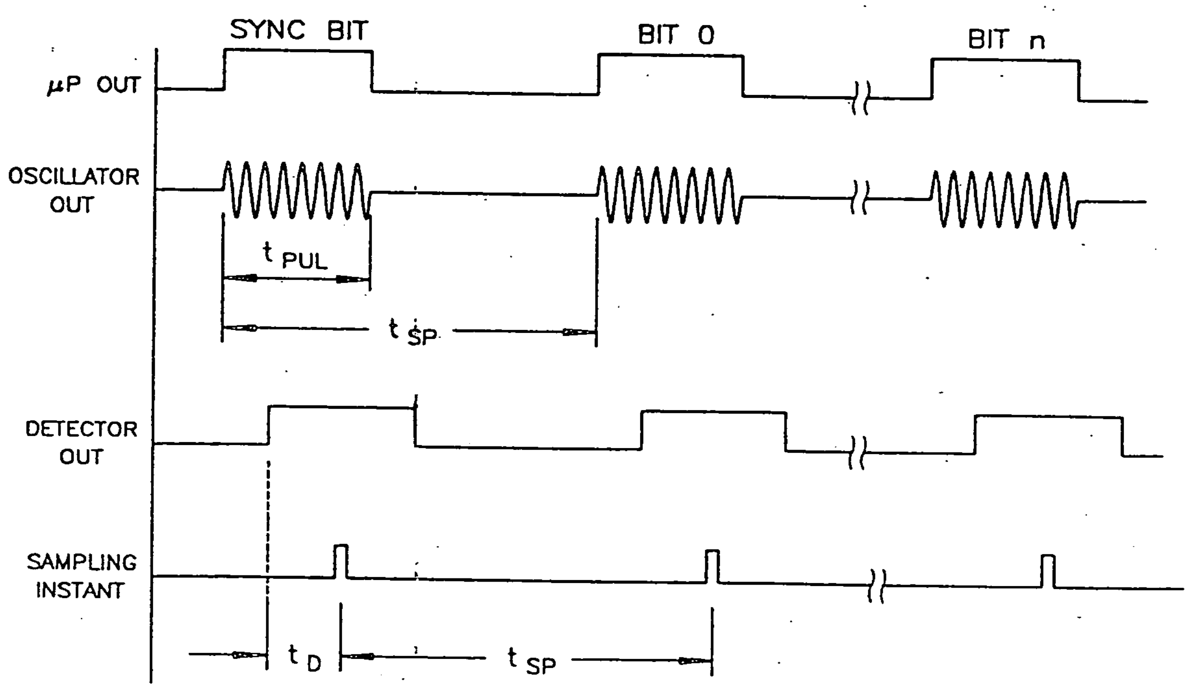

FIG 7

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